Technology Opportunity

Wave Rotor Technology

The National Aeronautics and Space Administration (NASA) seeks to transfer wave rotor technology design and performance assessment expertise.

Potential Commercial Uses

- Gas turbine engine topping cycles
  - Turboshaft engines: helicopter engines; general aviation; auxiliary power units; electric power plants; automobiles
  - Turbofan engines: large civilian transport engines; business jets
- Superchargers for internal combustion engines: improvement/optimization of existing commercial application
- High enthalpy test facilities: hypersonic wind tunnel; magnetohydrodynamic generator driver; weakly ionized gas studies
- Chemical reactors: high-temperature, quick-quench chemical production
- Gas flow joiners: thrust augmentors; ejectors
- Gas flow dividers: air conditioners; coolers; "ram" compressors (e.g., natural gas substation pressure boosters)

Benefits

- Performance enhancement: Wave rotor topping significantly enhances the specific power and efficiency of gas turbine engines as shown for some example applications in Table 1.
- Self-cooling: The wave rotor enables compression and heating to higher gas turbine engine cycle pressures and temperatures without exceeding current material temperature limitations.
- Low rotational speed: This results in low material stresses, allowing higher rotor temperatures.
- Efficient at low corrected flows: Excellent for topping modern gas turbine engines.
- Simple design: Potentially inexpensive to manufacture and mass produce.
- Rapid transient response: Excellent load following capability.
- Damage resistant: Robust construction and relatively low in-rotor velocities accommodate particulate-laden flows (e.g., as experienced when using less refined fuels).

The Technology

A wave rotor is a machine that uses gas dynamic (shock and expansion) waves within rotating passages to accomplish the work typically done by the blades of a turbomachine. Unlike a steady-flow turbomachine which either compresses or expands the gas, both compression and expansion processes are accomplished within the single wave rotor component; further, in some applications, combustion or chemical reaction takes place within the passages. Because the wave rotor walls are heated and cooled at very high frequency, the walls settle out at an

Table 1.—Predicted benefits of wave rotor topping in various gas turbine engine applications

Gas turbine engine application	Specific power ($hp/lb_m/s$) enhancement, percent	Fuel consumption ($lb_{m\text{-}fuel}/hr\text{-}hp$) enhancement, percent
Helicopter turboshaft engine	+18	-16
Electric power plant	+14	-12
Jumbo jet turbofan engine*	+1.8	-1.6

* These numbers translate to a significant 3% take-off gross weight reduction which means that the jumbo jet could travel farther or could travel the same distance with more passengers.

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average temperature which is significantly cooler than the peak gas temperature. The wave rotor can therefore be used in ultra-high temperature applications without resorting to exotic materials or cooling technologies. The NASA Lewis Research Center has expertise in wave rotor design methodology and performance assessment. A series of computational tools for simulating on-design and off-design performance have been developed and validated using data from in-house experiments. These methods have been used to design wave rotors for gas turbine engines and to predict the resulting performance benefits (see Table 1).

Options for Commercialization

One of NASA's missions is to transfer technology to U.S. industries. The NASA Lewis Research Center's aim is to transfer its wave rotor technology design and performance assessment expertise described herein. The potential applications for wave rotor technology are quite broad as indicated in the section entitled "Potential Commercial Uses." Among the industries which could potentially benefit from wave rotor technology are aeronautics (gas turbine engines), marine power (gas turbine engines), electric power generation (gas turbine engines), diesel engine power (superchargers), and chemical production (chemical reactors). NASA Lewis is actively working with an aeronautics gas turbine engine manufacturer to demonstrate wave rotor topping benefits in one of their production engines. NASA Lewis seeks industrial partners to cooperatively explore the benefits of applying wave rotor technology to other applications.

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Key Words

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